Printable, Novel CNT Inks with V2V™ Technology

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Canton, MA

Outline

- CHASM Overview
- Alliance with SWeNT
  - CNT Applications Development Center
  - Collaboration on CNT Inks
- Limitations of Current CNT Inks
- New CNT Inks based on V2V™ Technology
  - Uniqueness
  - Preparation and Application
  - Performance Testing
  - Commercialization Status

CHASM TECHNOLOGIES

BRIDGING THE GAP

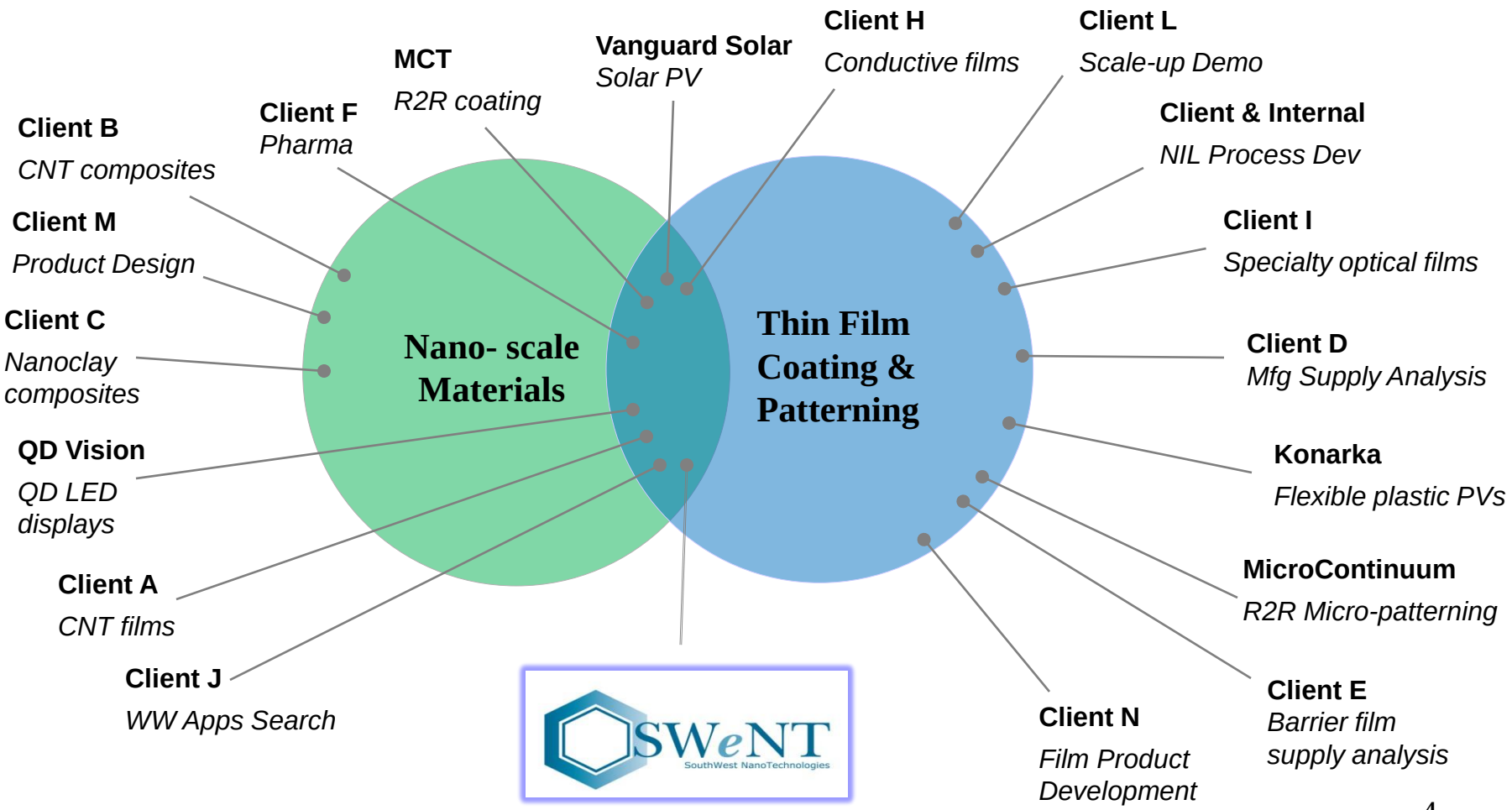
"Our mission is to help our clients commercialize new products through smart application of material science and process technology"

Founded March 2005. Located in Canton, MA. 9 Employees.

CHASM TECHNOLOGIES

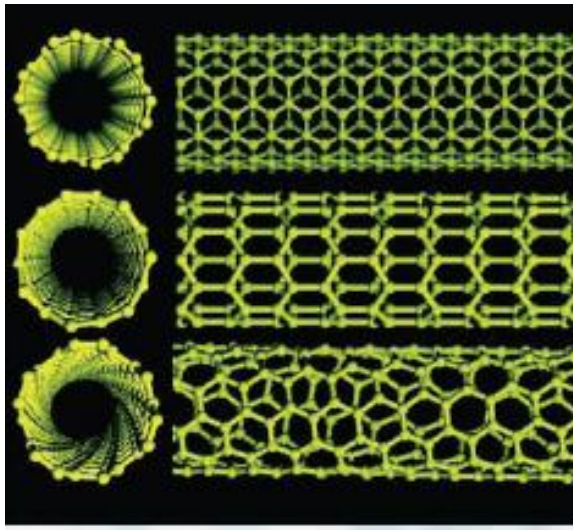
BRIDGING THE GAP

"Our focus is nanomaterials and thin film coating and patterning"

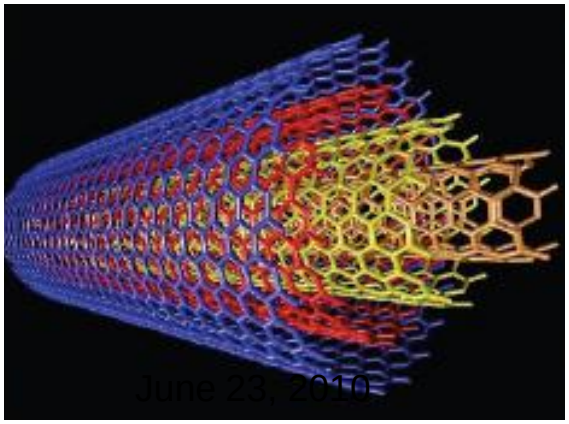


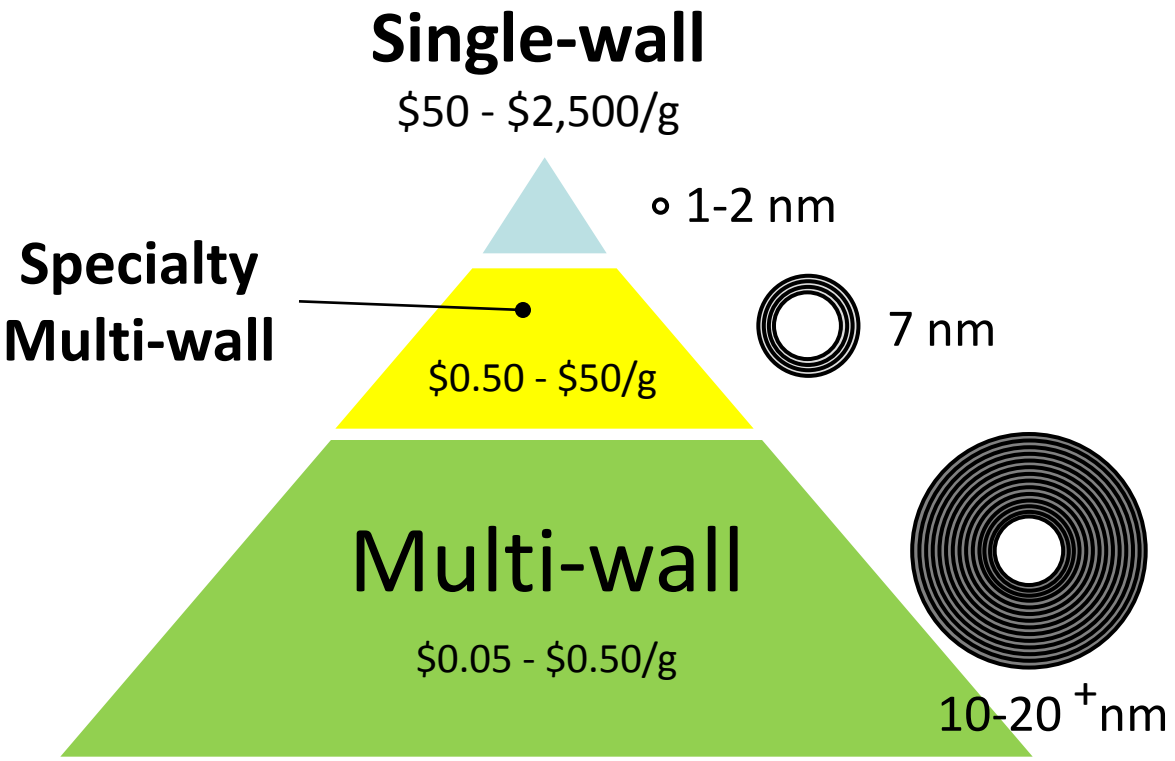
Carbon Nanotubes

Single-wall



Multi-wall



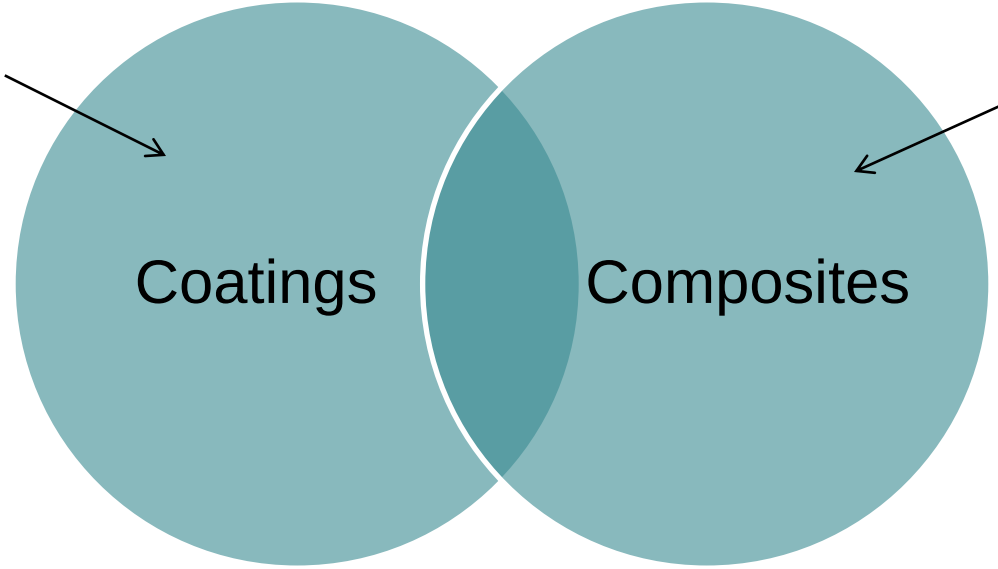


Business Model

"Tailor Tubes" for Target Applications

Single-wall

SG65
SG76
CG100
CG200
& more



SMW™

Deliver "Total Product Solutions"

Product Forms that are Easy and Safe to Use.

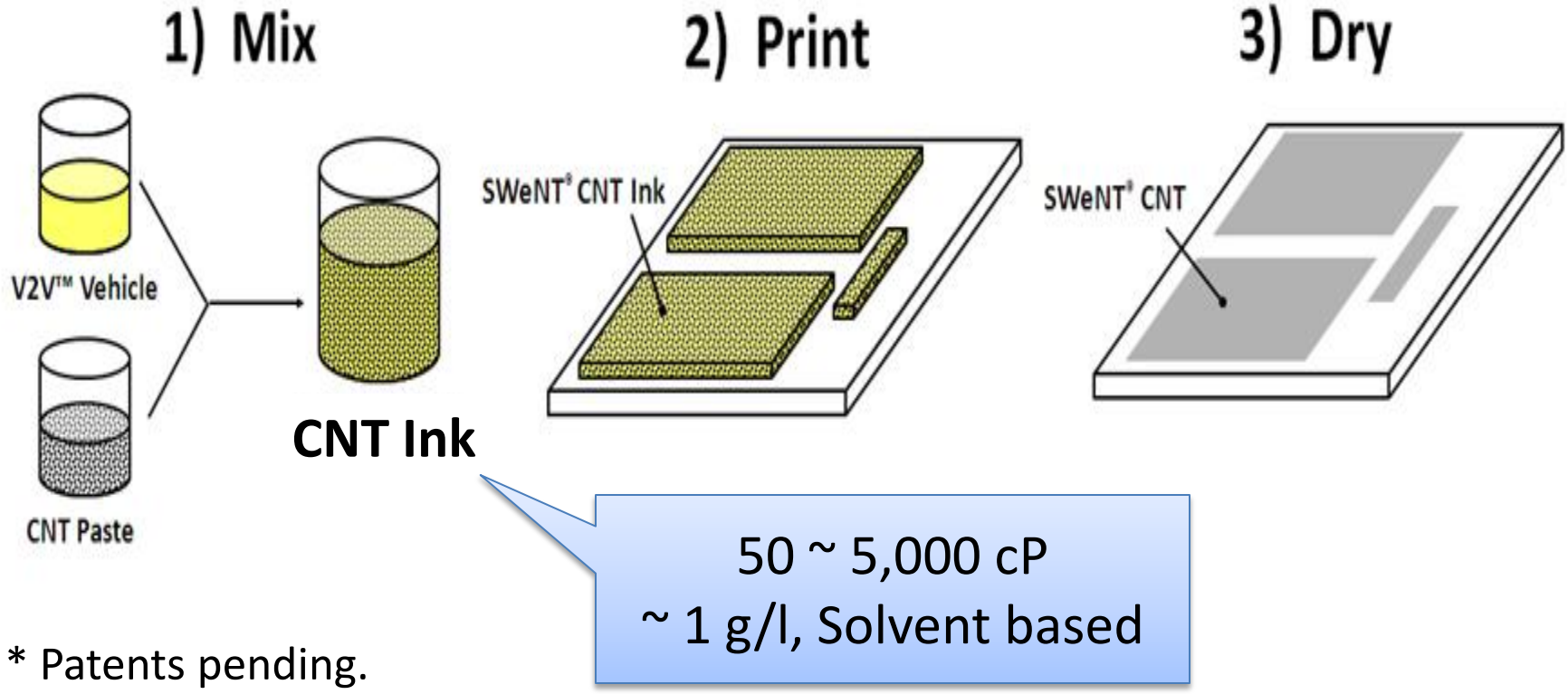
Collaboration with Alliance Partners and Customers.

Current CNT Inks

"Issues for Printing"

- Typical Application Methods:
  - Spin coat, spray coat, Ink jet
    - Low productivity / EHS issues / Subtractive patterning
- Typical Ink Formulations:
  - Non-volatile surfactants or processing aids
    - If not removed → Compromise CNT film performance
    - If removed → Adds process complexity / cost
  - Low viscosity
    - Incompatible with many "industrial" printing processes…
  - Low CNT concentration
    - Multiple passes required…

V2V™ Ink Technology*



* Patents pending.

CNTs printed using Standard Industrial Printing Equipment

V2V™ Ink Technology

Better – Chemistry Features

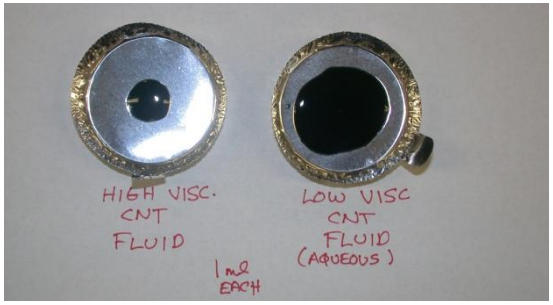
- 100% Volatile carrier fluid
  - No deleterious surfactants
  - No disperse aids required
  - 100% CNT Coating
- Formulation can modified to be compatible with substrate chemistry
- No secondary processes necessary to remove residual materials
- Works with a wide range of CNT tube types
  - Single Wall
  - Specialty Multi-Wall
  - Multi-Wall
- High CNT Concentration (at least 1 g/L)

V2V™ Ink Technology

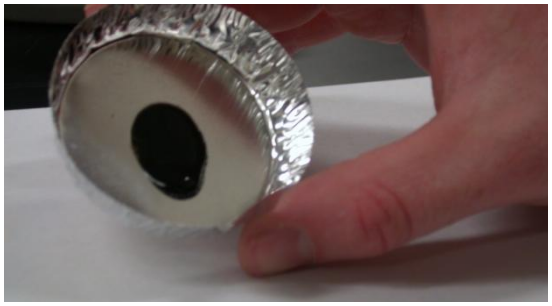
Better – Processing Features

- No special drying techniques/equipment needed:
  - Low processing temperatures – Can be as low as 85°C
  - Rapid drying – can be < 1 min.
- Viscosity can be tailored for coating application:
  - 50 – 5,000 cP
  - Screen, Wire Rod, Flexographic, Gravure…
- Compatible with a variety of substrates:
  - PET/Mylar, Polycarbonate, PVOH, EA, Cellulose, etc.
- Demonstrated print resolution of 0.3 mm

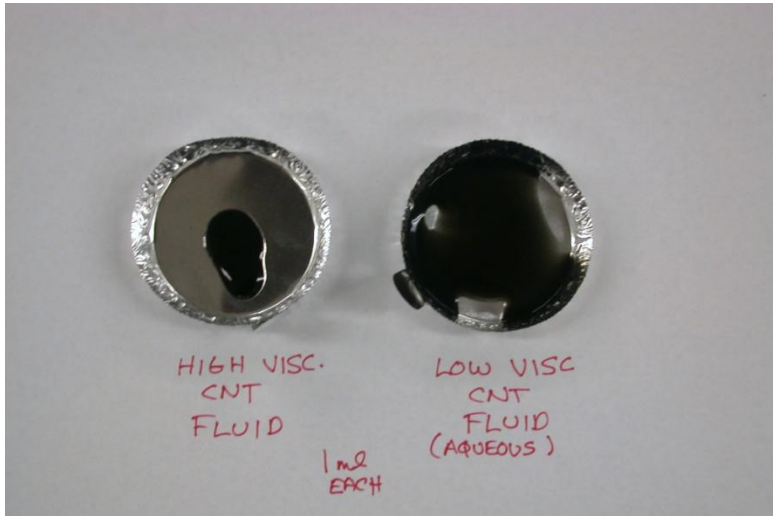
Viscosity Differences



1 ml of V2V™ Ink vs. Aqueous Ink

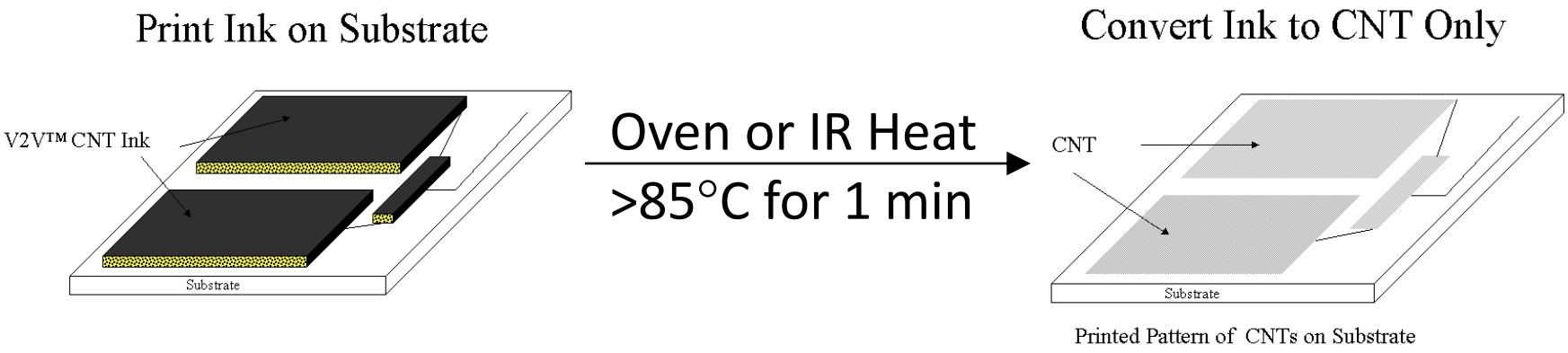


Tilting shows V2V™ Ink Resists Flow



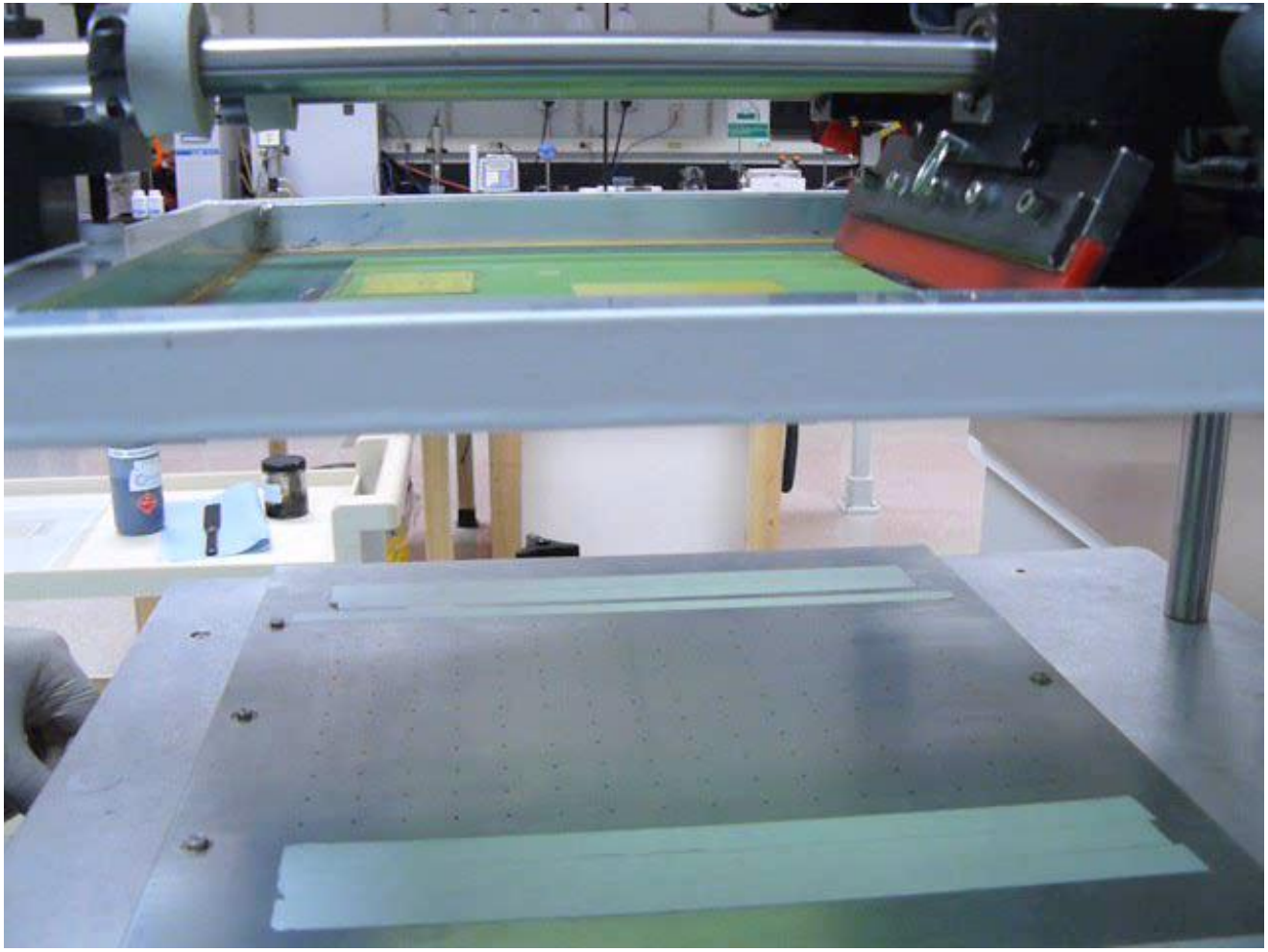
Same CNT concentration (1 g/L)

Simple Coating-Drying



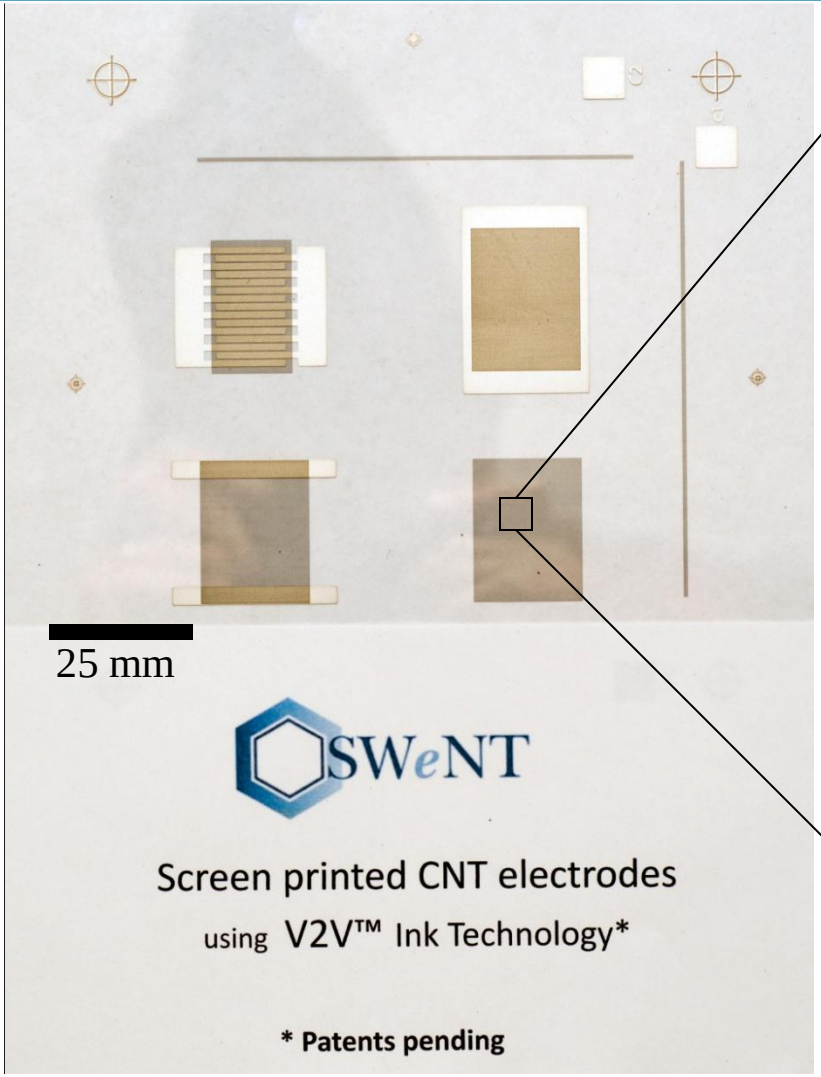
- Screen and Meyer rod printing demonstrated. Gravure, Flexo are next.
- Heating evaporates fugitive viscosity modifier and ink vehicle.
- Essentially 100% of the dried coating is CNT!

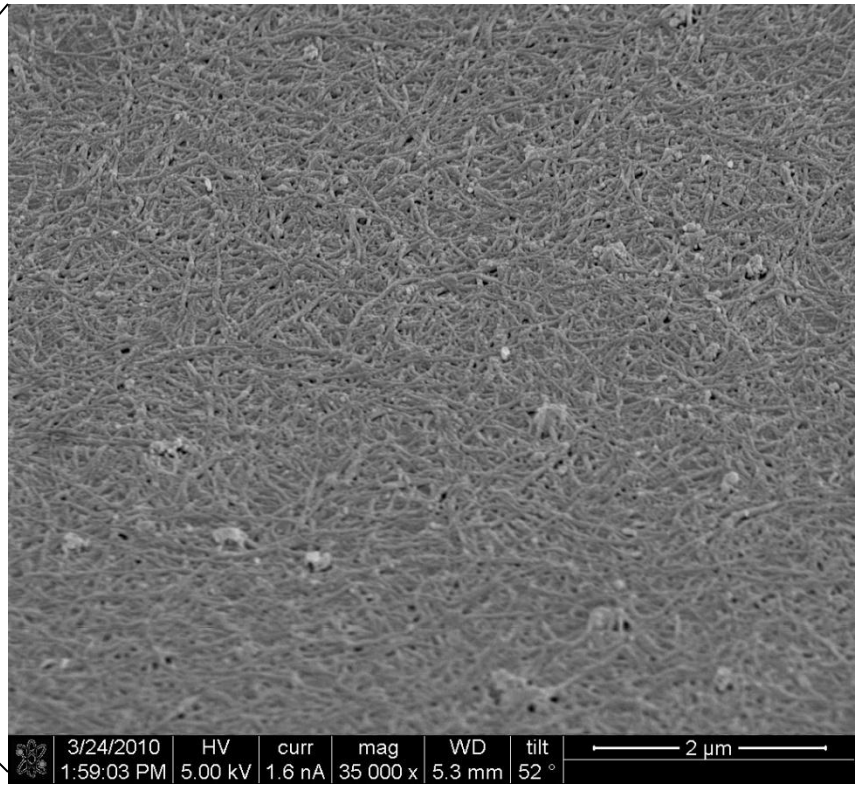
Successful Screen Printing*



* Courtesy of SWeNT Customer

Actual Devices Printed

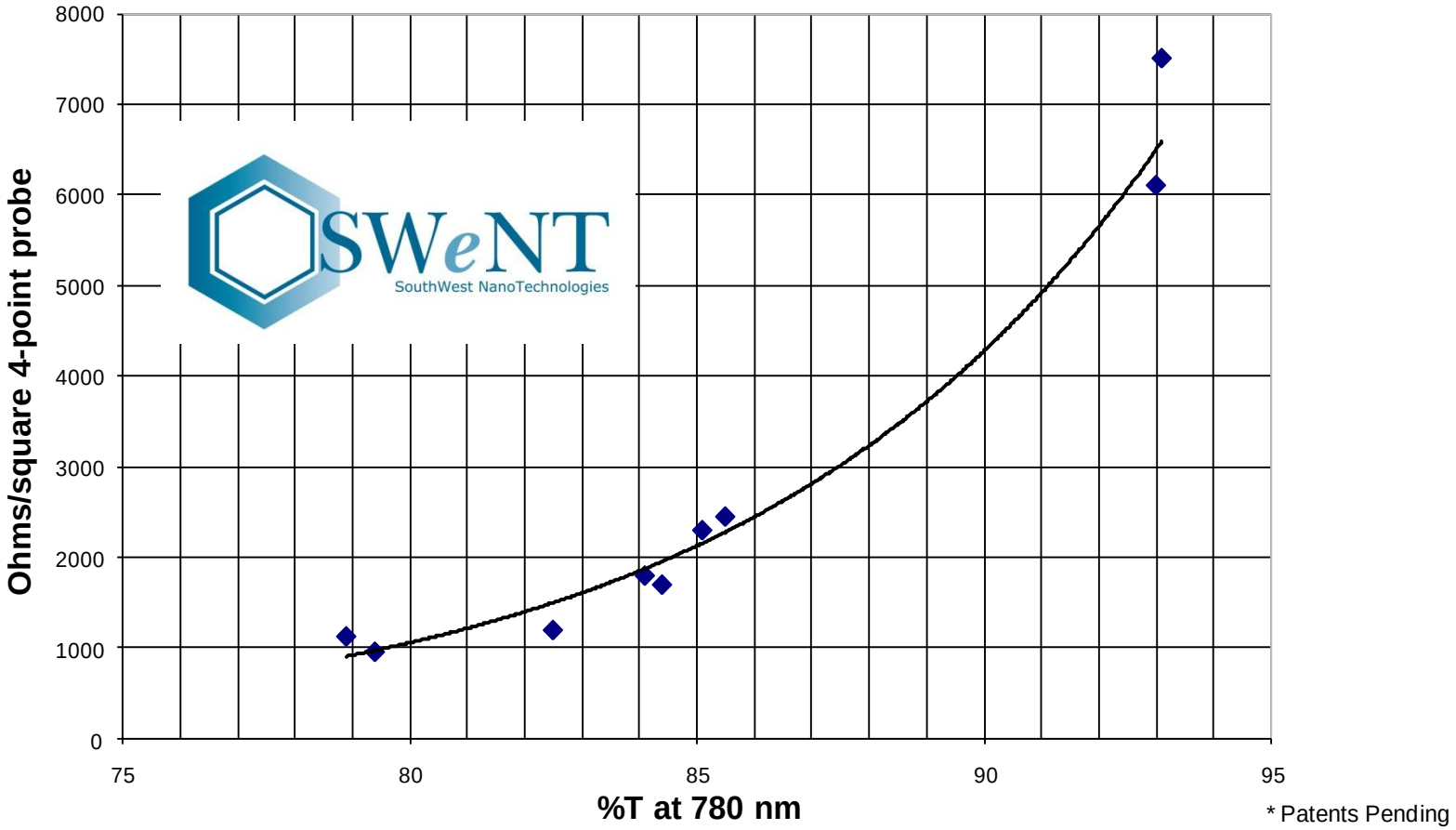




SEM Image Showing CNT Network

Performance of SWeNT® SG76 Ink

Based on V2V™ Technology



* Patents Pending

All Coatings were made in 1-Pass with different Meyer Rods and using a commercially available SWCNT from SWeNT.

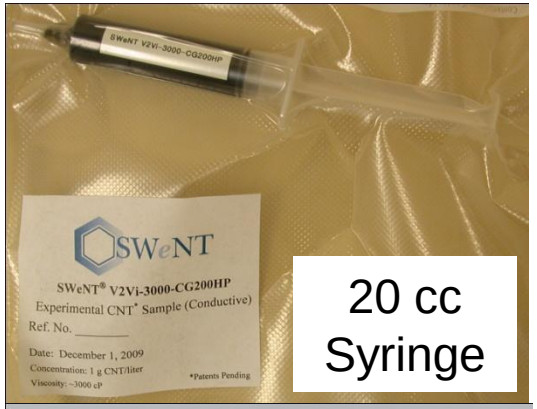
CNT Ink Applications

- Touch screens
- ESD Coatings
- Solar Cells
- Sensors
- Paper Lighting
- Paper Batteries
- ITO-film substitutes
- SMART Fabrics
- Flexible Circuits

V2V™ Technology Not Limited to CNT - Other Nanomaterials Could Be Used

Commercialization

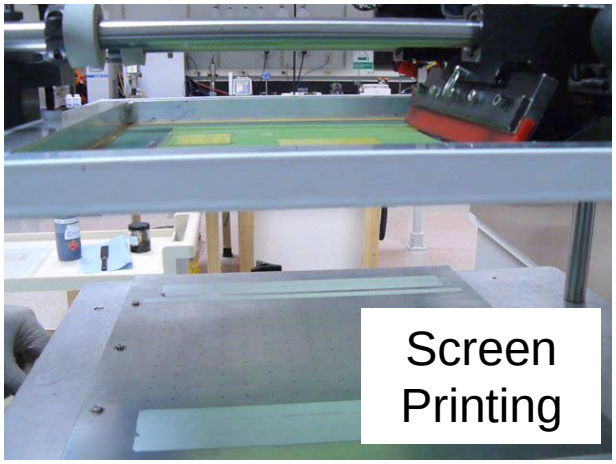
V2V™ Ink Technology*



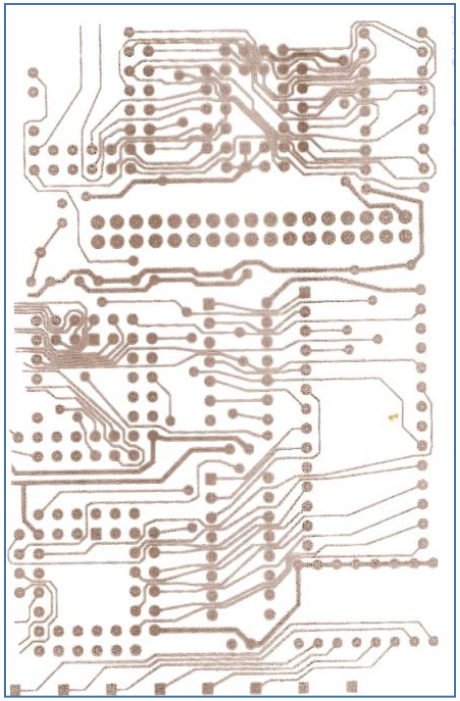
20 cc Syringe

1 liter Bottles

R2R Coating



Screen Printing



* Patents pending